# Optical Control of Metal-Insulator Phase Transition in In/Si(111) Nanowire

A. Okubo, Y. Terada, S. Yoshida, M. Xu, O. Takeuchi, H. Shigekawa
Institute of Applied Physics, Univ. of Tsukuba, CREST-JST, Japan
http://dora.bk.tsukuba.ac.jp/

Quasi-one-dimensional (1D) nanowires show interesting characteristic properties inherent to the low-dimensionality, for example, metal-insulator transition (MIT) of Peierls-type associated with charge density wave (CDW) observed at low temperature (LT) [1]. The quasi-1D nanowire formed on an In/Si(111) surface has a metallic $(4\times1)$ phase at room temperature (RT), which undergoes MIT to an insulating $(8\times'2')$ phase at 100K with the formation of CDW and periodic lattice distortion. Controlling the MIT using an external field is expected to open up new possibilities for applications such as optical switches and sensors. We recently found that MIT is reversibly controlled by changing the voltage applied between a scanning tunneling microscope (STM) tip and a sample, and more efficiently, by the laser irradiation to the sample.

In the dark condition, the metallic $(4\times1)$ phase dominates the surface for a negative sample bias voltage $V_s$ [Fig. (a)]. For a positive $V_s$, in contrast, the insulating $(8\times'2')$ phase partly appears [areas surrounded by the solid lines in Fig. (b)], indicating that the MIT can be driven by the external electrical field. However, the insulating area merely increases with $V_s$, and the surface is still dominated by the metallic phase even at higher $V_s$. For further advance of this controllability, we introduced an optical illumination process. As clearly shown in Fig. (c), the metallic $(4\times1)$ phase, which is dominant in the dark condition [upper half in Fig. (c)], wholly changes into the insulating $(8\times'2')$ phase under photoillumination [lower half in Fig. (c)]. We confirmed that the optical control of MIT is reversible, suggesting its high potential for the applications mentioned above. The details, including the MIT mechanism of this system, will be discussed at the conference.

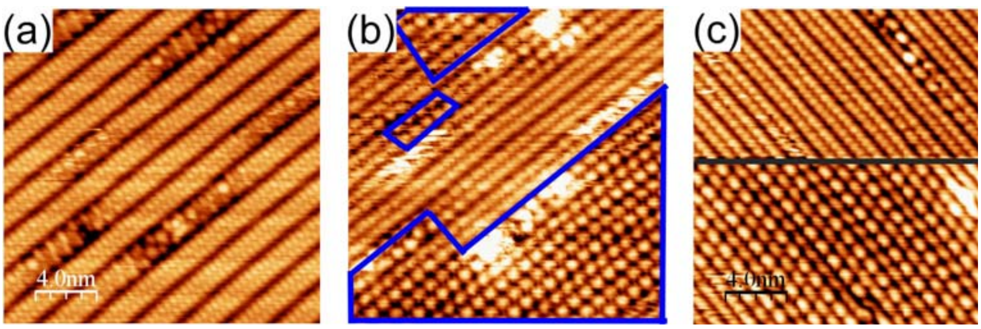


Fig. 1 STM images of an In/Si(111) surface ($I_t$ = 200 pA, 20 × 20nm$^2$). (a) $V_S$ = -1V, $T_S$ = 61 K. (b) $V_S$ =1V, $T_S$ = 61 K. (c) $V_S$ = 0.4 V, $T_S$ = 47 K. The lower half in (c) was taken under photoillumination.

**References**

[1] H. W. Yoem et al., Phys. Rev. Lett. **82**, 4898 (1999).